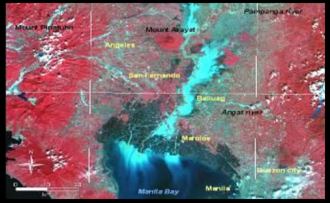
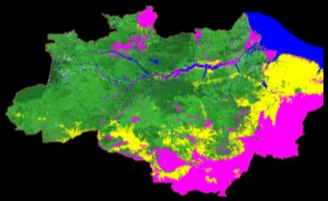




QA4EO Compliant QA/QC system for automated quality control of large satellite Constellations

Steve Mackin (DMCii)

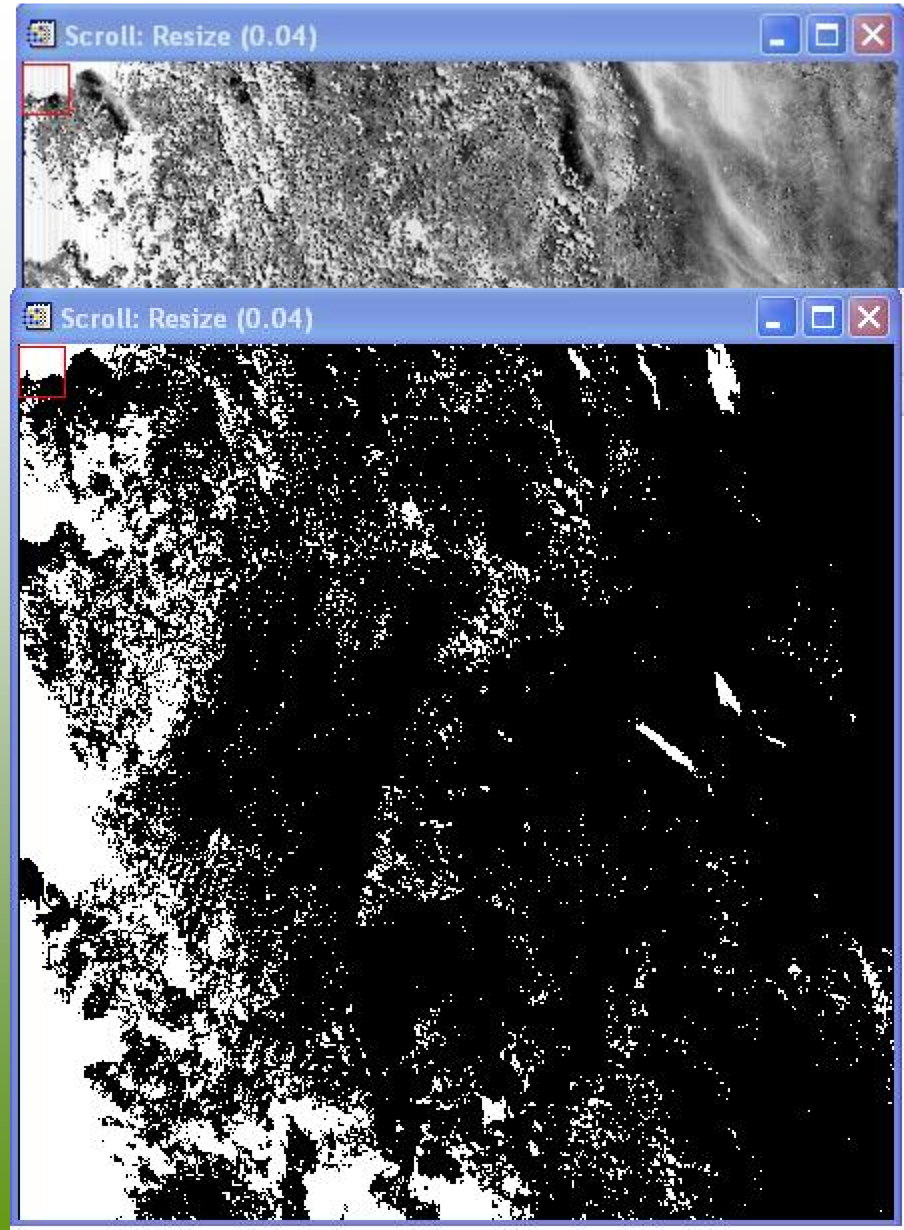
Presentation

- Current QA/QC at DMCii
  - Does it tell you how good the data is for your purpose ?
- What is QA4EO ?
- Quality Indicators
  - Uncertainty per data product ?
  - SNR ?, calibration uncertainties ?
- How do we do this ?
- Where will DMCii be in 2011 with QA/QC?

International Imaging

Current QA/QC at DMCii

- Fairly standard methods,
  - Saturation (see map right)
  - DN range of RAW data
  - Column odd/even pixel offsets
  - Row odd/even pixel offsets (temporal)
  - Reference pixel check
  - Calibration check (where appropriate)
  - Artefacts (vertical or horizontal features in data)
  - Long term radiometry exceptions (time series monitoring)
  - Radiance Range
  - Bank to Bank radiometry differences
  - Signal to noise ratio
  - Geometric accuracy



International Imaging

Current QA/QC

DU000fe7sm.imi_LOG.txt - Notepad

File Edit Format View Help

```
F:\DMC Data Xmas\DU000fe7sm.imi
Number of Lines = 8127
Number of Samples = 8784
Centre Offset = 0
Channel Number = 7
Bit Depth = 8
Line Duration = 6000
VGA Gain - Green = 14
VGA Gain - Red = 125
VGA Gain - NIR = 230
CDS Gain - Green = 42
CDS Gain - Red = 42
CDS Gain - NIR = 42

SPLIT FILES

SATURATION CHECK
Saturated Pixels Green = 2023207
Total Pixels = 71387568
Saturation % = 2.83412
Mean Value = 166.849
Saturated Pixels Red = 4308060
Total Pixels = 71387568
Saturation % = 6.03475
Mean Value = 171.515
Saturated Pixels NIR = 21916216
Total Pixels = 71387568
Saturation % = 30.7003
Mean Value = 186.914

DN RANGE CHECK
Green Histogram (%)

0        20.2718
1        1.26072e-005
2        1.68097e-005
3        1.96113e-005
4        1.54088e-005
5        2.38137e-005
6        2.66153e-005
7        0.00569287
8        0.0262665
```

- Example of log file
  - Log file covers all checks in a simple manner
  - Key elements being moved into metadata
  - Not necessary to use this quality data (we expect few users will be interested), but can be accessed by the end user
  - Process is partly automated. Next change is to introduce thresholds for e-mail alerts and process control.
  - Automated version will go live later this year.

Current QA/QC

- Does it answer how good the data is ?
  - Not really, its an overview that is more of use to the operations team
- What is the alternative
  - Provide an uncertainty on every pixel in every scene. If the radiance is 50 W m^{-2} sr^{-1} μm^{-1} we can say (for example) the uncertainty on that value for that single pixel is 3.8 W m^{-2} sr^{-1} μm^{-1}

Quality Assurance for Earth Observation (QA4EO)

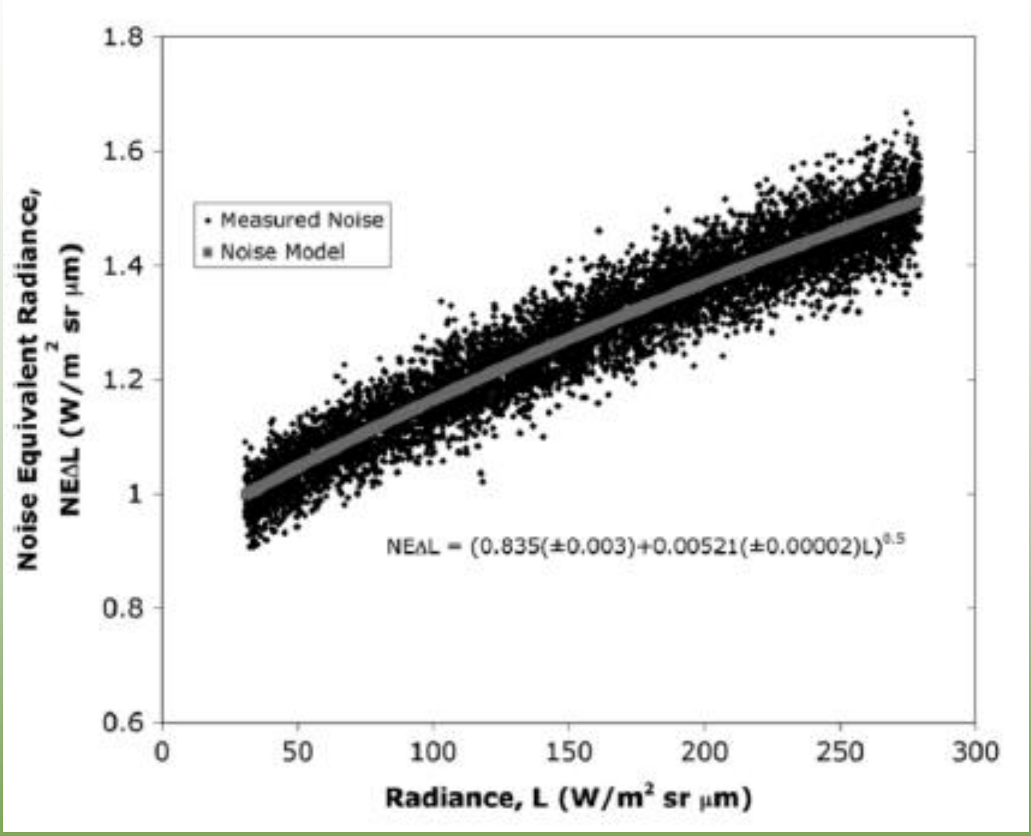
- Origins in CEOS WGCV
- http://qa4eo.org
- Aim is to provide a framework to guide the development of a QA/QC system that can provide quality information at the pixel level for all data products.
- Level 0, Level 1, Level 2, in-situ data
- Primary aim is to define uncertainty at the pixel level and provide the evidential trail (traceability) to national and international standards.

Quality Indicators

- Why do we need this level of detail ?
  - In Europe for the planned GMES services to the European end-user to allow the end-user to select the data products that most suit their requirements
    - Might be cheaper for the end-user to buy data with higher uncertainty on the data product, but still acceptable for the application
    - The end user application may require limits on the uncertainty of the input data for model requirements for example in climate change studies.
  - To allow third party vendors to assimilate the uncertainty in their value added products
  - To allow end-users such as the USDA/USGS/GMES to evaluate the data based on a quantitative measure readily available at minimum cost and compare to other data providers in a direct manner.

Quality Indicator – Examples (noise)

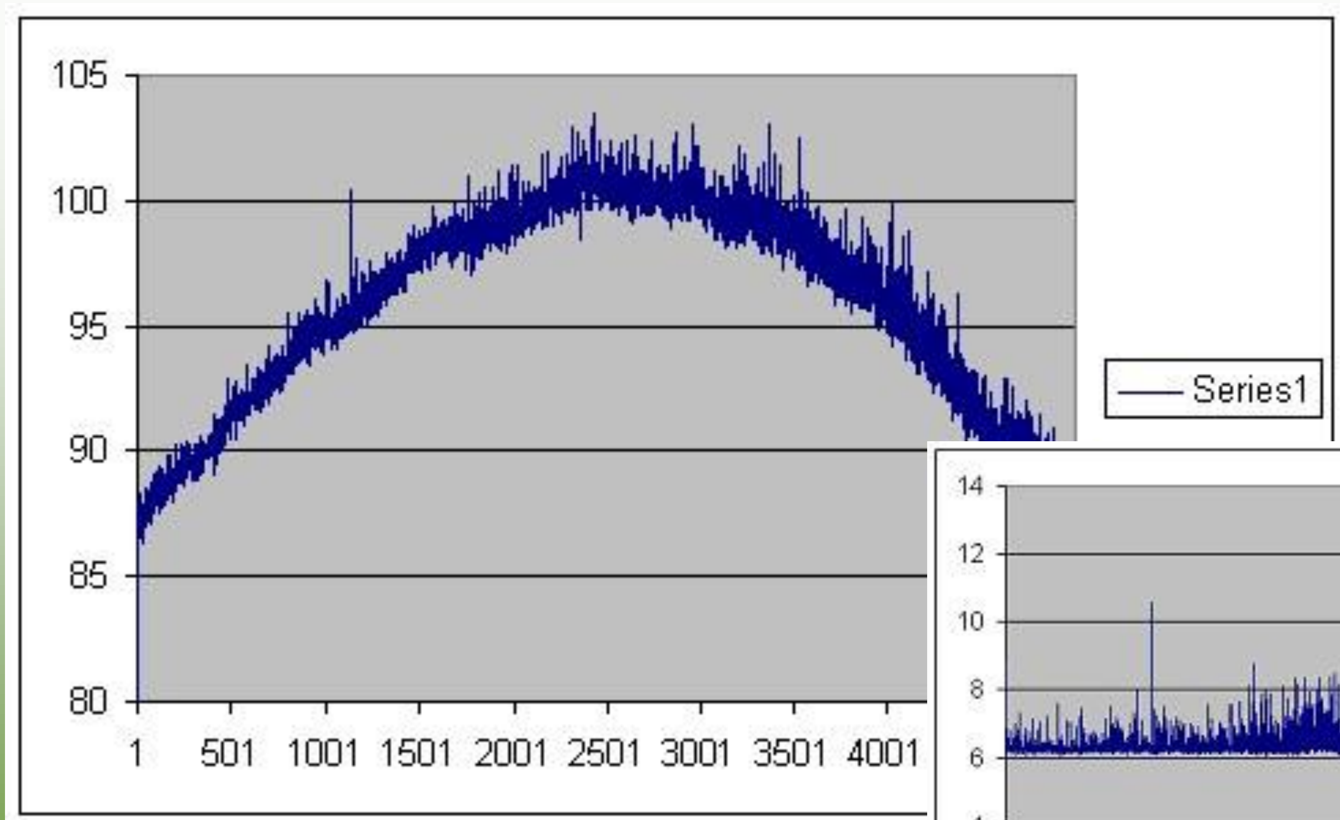
- A single SNR value does not capture the uncertainty and has no direct use
- The noise contribution is dependent on the signal (in part), therefore the uncertainty of a measured value varies depending on the value itself. So a **pixel level** measure



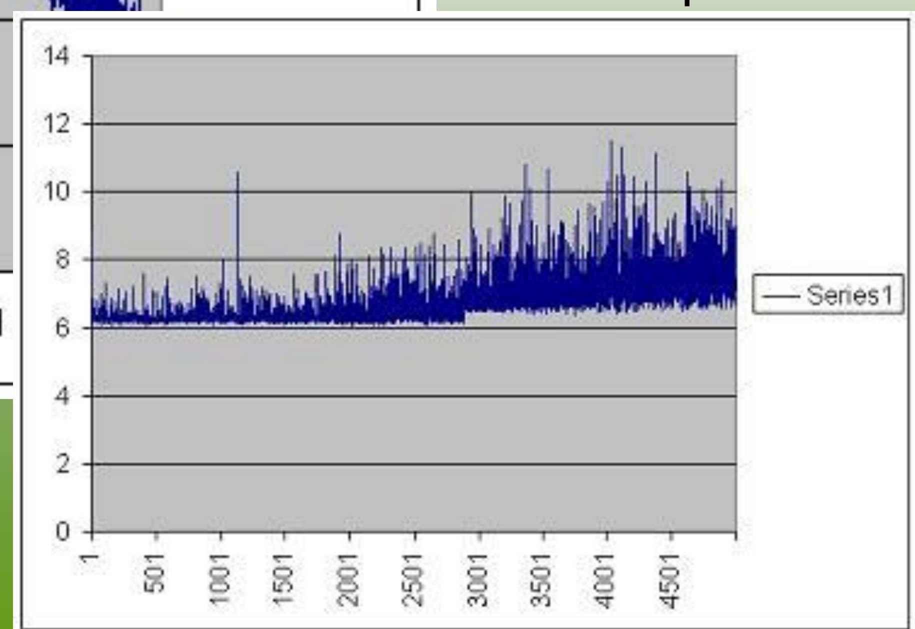
Landsat 7 – Blue band

Quality Indicator – Examples (noise)

Vignetting



DC and pattern



Quality Indicators

- Quantification at different levels and flags still required
  - Noise contribution to a data value is dependent on the **detector** response (pattern noise), the **pixel** brightness and the position of the **detector** on the array (vignetting)
  - Calibration is usually considered at the **band** level

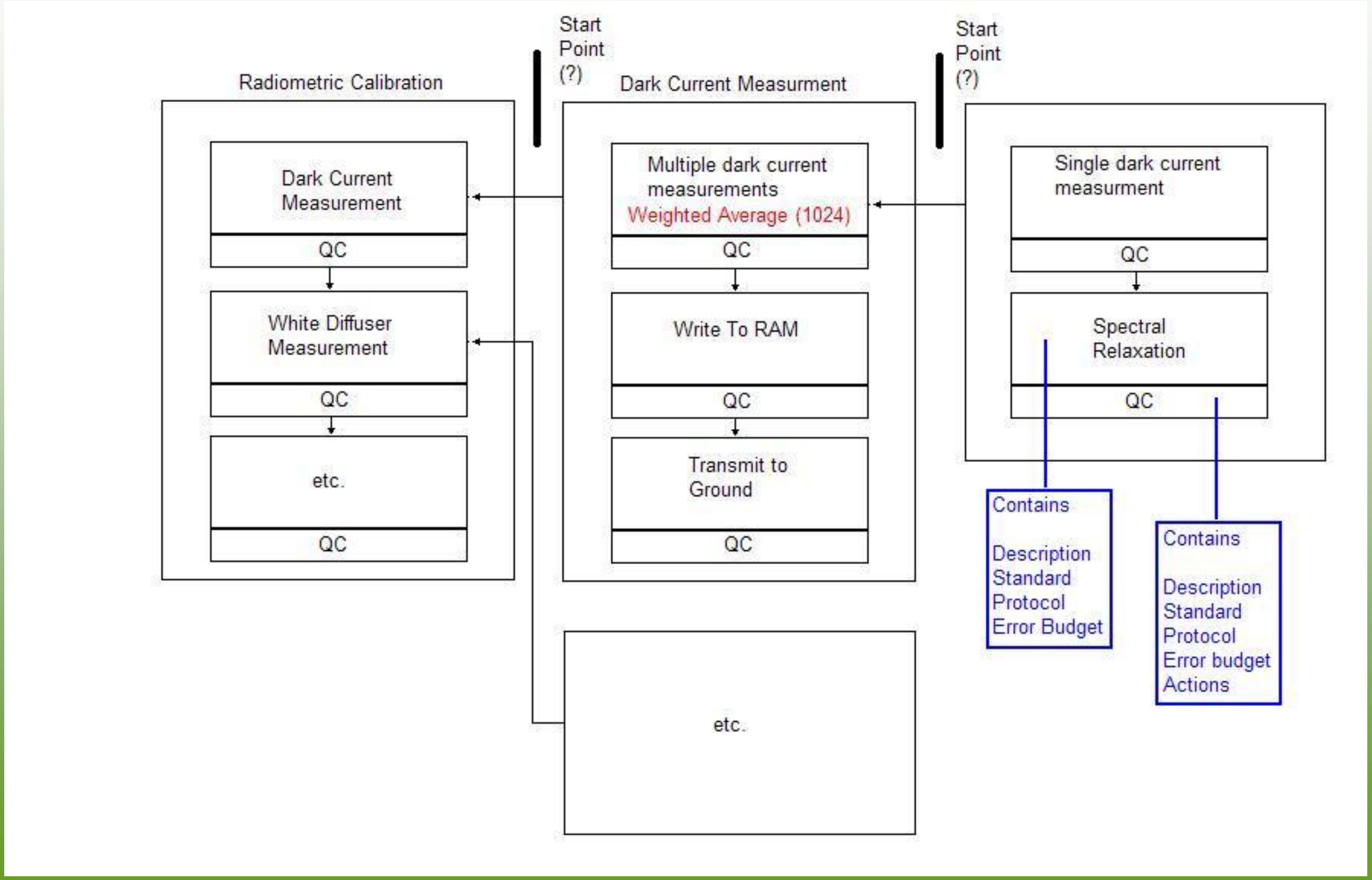
Why quantify this ?

- When you create an NDVI product, how good is it…?
  - Red = 20   1
  - NIR = 60   1.2
  - NDVI = 0.5   0.026

- The uncertainty is much more useful than an instrument specification with a “Signal to Noise Ratio of 120-1” with no given conditions of measurement

What sort of approach to consider ?

- Approach based in part on an ESA multi-mission generic QA/QC project report (NPL)



What sort of approach to consider ?

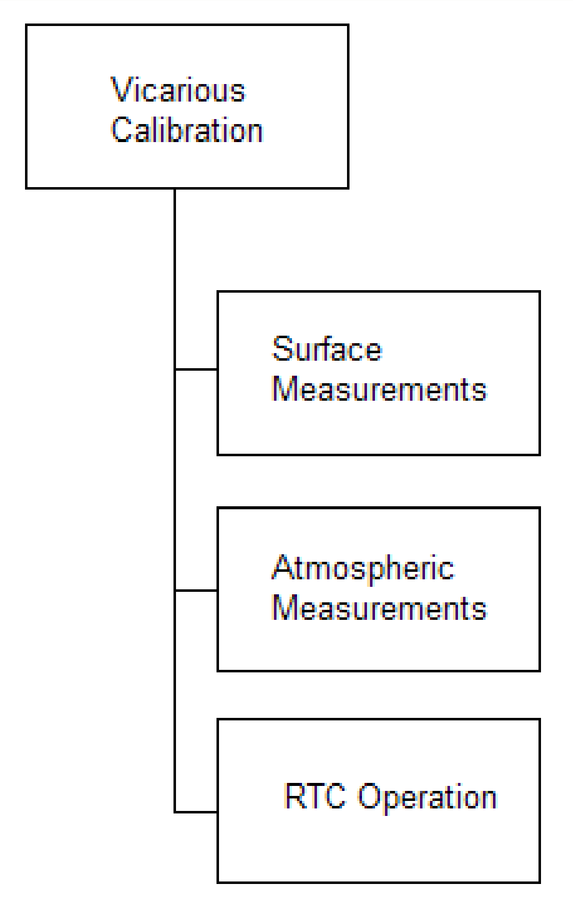
Steps

1. TOA Radiance Product
    a. Absolute Calibration (5 acquisitions)
        i. Generation of TOA radiance (band integrated value)
            1. Ground data collection at RRV
                a. Instrument and Panel Calibration
                b. Surface Measurement
                c. Surface Variability across site
            2. Atmospheric analysis at RRV
                a. Instrument calibration
        ii. DMC Data Collection at RRV
            1. Surface Variability across site
            2. System noise (two pixel average)
            3. CCD stability – odd/even pixels
            4. CCD stability – CCD cross array variability
            5. Dark Image
        iii. DMC Transfer to Dome-C
            1. Surface Variability across site
            2. System noise (large column average)
            3. CCD stability – odd/even pixels
            4. CCD stability – CCD cross array variability
            5. Atmospheric variability
            6. Dark Image
    b. Cross-Calibration (19 image pairs)
        i. DMC Collections over Dome-C
            1. Atmospheric change between overpasses
            2. Surface variability
            3. Accuracy of pointing
            4. System noise (per overlap area)
            5. CCD stability (per overlap area)
            6. Dark Image Collection
            7. Absolute Calibration accuracy (from above)
            8. Calibration drift
    c. Calibration Drift (many images)
        i. DMC collections over stable sites
    d. TOA Radiance product
        i. Variability in target brightness (hence noise)
        ii. Absolute calibration after transfer via cross-calibration and adjustment for calibration drift.
        iii. CCD stability

- Lots of steps…!!
- Each one is an individual module with documentation that meets QA4EO standards
- Each one has a QA Element **and** corresponding QC element
- So first step is breaking down our current activity into such small steps

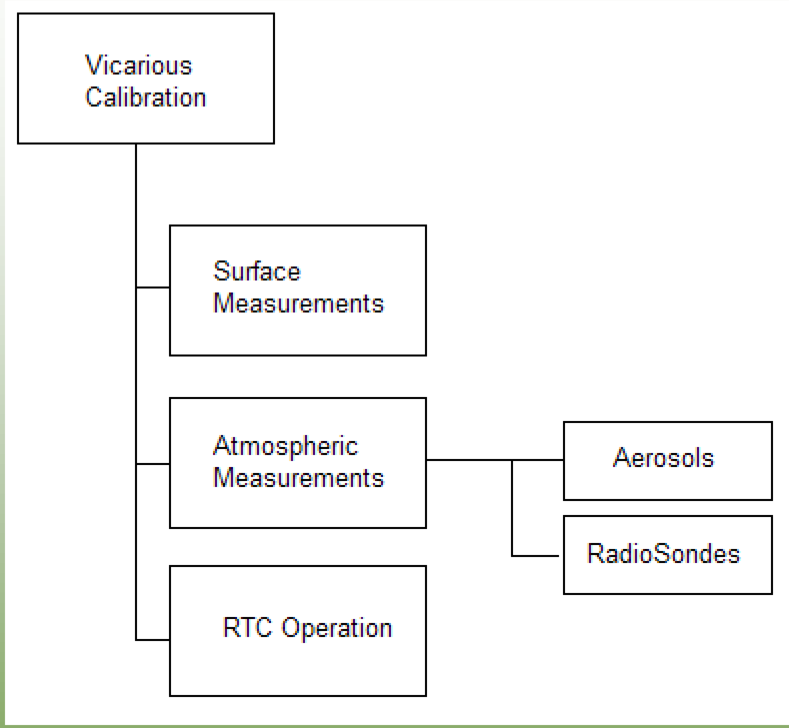
Module Creation

- Generic and final physical implementation
  - Implementation initially of modules for a selected satellite *(very time consuming)*
  - Reuse of some of these (non-specific) modules with minor changes to structure *(rapid development)*
  - Example : Vicarious calibration module has same sub-modules (surface measurement, atmospheric measurement, model. Can be reused for different satellite systems with minor amendments
  - These reusable modules become a generic (non-specific) component

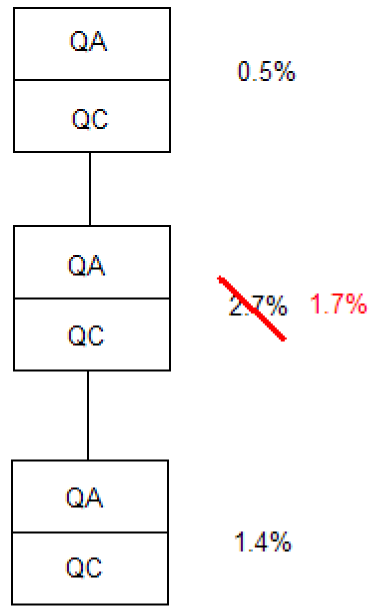


Module Creation

- Management modules (aggregation)
  - Modules at such a fine level are difficult to manage
  - In last slide Vicarious Calibration consisted of three sub-modules
    - Ground Reflectance Measurements
    - Atmospheric Measurements
    - Radiative Transfer Code
  - Each of these may contain lower level modules
  - Need for an aggregation function still allowing flexibility, but also easier flow control

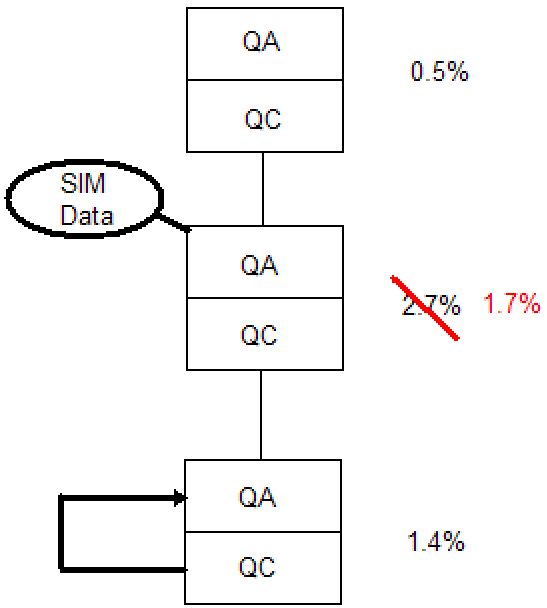


Creating a flow



- Linking Modules requires simply connecting them in sequence
  - Requires common interfaces
  - Ability to pass parameters and intermediate data
  - Uncertainty passed and combined at each level and checked using QC check (if possible)
  - Modules can be changed by swapping them out of the flow and replacing them with something else with lower uncertainty
- Passing information
  - Either using dummy variables in a call or
  - Using text or other files for intermediate storage and software that can read these intermediate files.

Process Control



- Simulation
  - By connecting modules using the QA component we automatically determine uncertainty for new systems.
  - Can run dummy data through and check the QC process at each step
- QC Control on process
  - QC is not only to validate the output from the QA
  - Has its own methods which allows in an integrated system, the QC to modify the way the data is processed at the previous step and hence modify the uncertainties (if required)

Issues

- Versioning
  - Changing a single module changes the whole output, so every MODULE needs to be versioned
  - This information needs to be passed through the system and stored in some manner so correct modules can be applied for any retrospective drill-down to the data
- Data Volume and processing
  - To store all intermediate uncertainties would require a large volume, to process to derive these for a user would be heavy on processing.
  - We expect almost all users will not drill-down
  - We have chosen to use a break-point and process method which stores some intermediate products and processes from these breakpoints.

Where will DMCii be in 2011 ?

- Developing following elements
  - Modular structure, one module per processing step
- Automated QA/QC
  - Remedial action
  - Operator e-mail
  - Process halting
- Produces uncertainty information for each step
  - Allows identification of problematic steps that can be replaced to lower uncertainty
  - Users get access to the quality data if they want it (fully transparent, including all methodologies used in the data processing and product delivery)

Thank You!

- www.dmcii.com
- www.sstl.co.uk

Sustainable Earth Observation